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TOWARDS A COMPARATIVE AND EVOLUTIONARY APPROACH TO COGNITION: REPLY TO COMMENTARIES

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The four commentaries are interesting in two respects: first, in that they raise a number of further issues about animal cognition; and second, because they show how many different positions can be entertained on this matter. While Christopher Robinson clearly rejects the cognitive approach as an alternative to behaviorism, Robert Boakes has no basic objection to animal cognition, but focuses on its actual contribution and reminds us that the positive legacy of behaviorism should not be thrown away with the bath water. Within a comparative approach to cognition, Gordon Gallup suggests that the best framework for generating testable hypotheses is the study of complex mental processes like self-recognition and reflective thought. On the other hand, Jean Pierre Rossi raises the problem of identifying the lowest evolutionary level at which the existence of representations can be assumed. In the following, we shall try to briefly discuss the main points that have been raised.

Christopher Robinson takes up William Mace's suggestion to "Ask not

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what's inside the head, but what the head's inside of." Let us emphasize that we see no reason why one should ask just one of these two questions, and not both. The fact that our paper was about the first one does not imply that we take the other to be less relevant: we believe that no single approach is able today to provide a complete explanation of behavior. Anyhow, at least human cognition is a matter of fact requiring an evolutionary explanation. Certainly, evolution theory is not seriously considered in present day cognitive science, but we believe that an innovative contribution in this direction could be brought about by a comparative perspective.

The cognitive approach does not restrict the object of study to what is "in the head," but rather it extends the study of behavior to what is "in the head." Certain branches of cognitive science, and notably artificial intelligence, have indeed restricted their attention to internal processes; but the literature of animal cognition and cognitive ethology already shows a more integrated view that takes ecological aspects into account. After all, adaptation and evolution have always been central issues in comparative psychology; animal cognition does not break with this tradition.

According to Robinson, cognitivism contains "an *a priori* assumption that tends toward anthropomorphism." Cognitive scientists rely on *a priori* assumptions as all other scientists; there is nothing vicious in this, provided that such assumptions are used to generate hypotheses that can be empirically tested. As regards anthropomorphism, we do not view it as a tendency, but rather a source of inspiration for building theories; and we should note that the scientific procedure is to verify the predictions, and not the origin, of a theory. Moreover, to look for similarities and differences in mental processes of different species is well within the tradition of comparative psychology, and fits an evolutionary perspective.

The controversy on the location of the psyche is too vast to be dealt with here in sufficient detail. By their very nature, mental states have a content and thus presuppose an external world; nevertheless, they are states of a precisely delimited physical system, namely, the brain, that happens to be located in the head. And as regards the environment, by itself it does not contain information, but mere physical processes that become informative when an organism can interact with them in an appropriate way. The reason why polarized light carries relevant information to bees and not to us is not to be found in the environment, but somewhere inside the bees' tiny heads.

Robert Boakes gives a clear summary of the reasons in favor of a comparative approach to cognition, and emphasizes a further point, namely the crucial link that animal models provide to neuroscience.

As regards the "mental hygiene" deriving from the experimental tradition of animal psychology, Boakes remarks that in several areas of cognitive science computational models are considered as a safer tool. In

our opinion, however, the experimental tradition and computer simulation should be regarded as complementary rather than competing. Correctly used, computers can improve the "hygienic conditions" of research, but by themselves they are unable to assess the correspondence between theoretical models and real phenomena.

We agree with Boakes on the importance of the behavioristic legacy, i.e., seeking explanations of behavior at a conceptual level distinct both from the neural level and from everyday folk psychology. In no way can mind substitute for behavior: it is a possible source of explanations for behavior, as well as being itself something to be explained.

Clearly, mental explanations require that certain constructs, used to explain other processes, are taken as elementary and unexplained. For example, the behavior of a given organism could be explained assuming that the animal stores certain cues in memory; but then, the capacity to do so is taken as a primitive. In turn, primitive processes might find an explanation at a lower level: it is in this sense, we believe, that the neural level can explain capacities that at a cognitive level can only be described. A similar relationship between two levels of explanation is common in science, and is well exemplified, for instance, by the relationship between thermodynamics and statistical mechanics.

From our standpoint, however, the main contribution of animal cognition to cognitive science is the phylogenetic and comparative perspective that it brings in. The point is not only to shed light on human cognition through the study of animals, but rather that if cognition is a natural phenomenon with an adaptive value, it plausibly extends beyond the human species.

Gordon Gallup suggests that, besides the two approaches to cognition we have discussed, there is a third approach, which he refers to as "reflective mind." It seems to us that this is not a different approach, but rather a specific and extremely interesting area of investigation, that can only be tackled from a cognitive perspective. Reflective representations are a specific type of representations, and, therefore, have to be interpreted either as mental states with content or as IPP structures.

Gallup quite correctly remarks that the reflective mind hypothesis provides a framework from which interesting testable hypotheses can be generated. However, such hypotheses presumably apply only to primates, and not even to all of them; as interesting as this area may be, it does not exhaust the field of animal cognition. The paradigms discussed in our paper are intended to cover a broader range of phenomena; moreover, the research by Dickinson and his colleagues, as well as other studies reported in the literature, suggest that both the semantic and the IPP approaches are suitable for experimental investigations, and thus are no mere metaphors.

The urge to broaden the scope of animal cognition justifies our claim that "... self-awareness and thinking about the process of thinking itself

are by no means necessary components of cognition." Of course, this does not mean that they should not be regarded as possible components, and well worth studying. We agree that they should not be too quickly dismissed—the history of psychology shows, however, that sometimes they have been too quickly accepted.

The focus on the reflective mind is an example of a positive product of anthropomorphism, that is the use of human experience as a source of testable hypotheses on other species. But this does not rule out the impossibility to grasp the phenomenology of the experience of other organisms, which is a consequence of the subjective nature of the mind.

Jean Pierre Rossi attributes to us the opinion that there are no major difficulties in studying animal cognition. Perhaps we are not that optimistic. We believe that there are in principle no methodological grounds to reject models of animal behavior based on cognitive constructs, and that establishing which animals, if any, have mental processes is a theoretical question of fundamental importance, that deserves an intensive research effort. However, this path is not without difficulties. It is true that similar problems are faced by those who study newborns or infants in a prelinguistic stage; but here we are still dealing with the human species, of whose mental life we are fairly confident.

It is not possible to define *a priori* at what evolutionary level the cognitive approach can be profitably applied. Representations cannot be directly observed; therefore, the initial evidence that representations do exist can only derive from the success of models that postulate them to explain behavior. As remarked by Rossi, it is the predictive power of models that has to be assessed; only after sufficient evidence of this kind is available, will it be possible to correlate the existence of representations with the complexity of the nervous systems, the existence of cortical structures, etc. What we know today is that our neural structures are sufficient to realize cognition, but we do not know what kinds of neural structures are necessary for representations to exist. Only a comparative and interdisciplinary approach can lead to positive results in this direction.